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ABSTRACT

The objective of this research study was to determine the graduate education needs of North Carolina's mathematics and science teachers. Federal and state mandates require a restructuring of graduate education in order to focus on professionalism in teaching. To validate this top-down approach, mathematics and science teachers were asked to tell about their professional development needs. The study consists of two parts. The first part examined 467 teachers' anonymous responses to a paper and pencil survey. The emphasis in Part One was to gather information about the teachers' needs with regard to the curriculum aspects of graduate study. Researchers interviewed teachers individually in Part Two of the study to determine the pedagogical issues associated with university instruction. Considering that learning is a process of making meaning, teachers recognize the importance of understanding how students learn. It is from these and other contemporary perspectives that the study of teaching and learning emerges as a key element of graduate education for science and mathematics teachers. (ASK)

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CONSIDERING SCIENCE AND MATHEMATICS TEACHERSí NEEDS WHEN RESTRUCTURING GRADUATE EDUCATION

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Objectives and Significance

The objective of this research study was to determine the graduate education needs of North Carolinaís mathematics and science teachers. Federal and state mandates are requiring a restructuring of graduate education in order to focus on professionalism in teaching. To validate this top-down approach, we asked mathematics and science teachers to tell us about their professional development needs.

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Over the past ten years, school reforms have been proposed to move curriculum, teaching , and assessment away from the educational objectives established during the industrial age. Beyond curriculum revisions, changes were first proposed for K-12 teacher preparation, K-12 teacher development, and K-12 student achievement. While moving forward along these lines remains an important focus of federal and state reforms, other dimensions were added to accomplish the action agendas of reform. Understanding that short courses and workshops do not have the necessary impact on teacher change and student achievement and to effect sweeping changes in teaching practice, two strategies were added to the reform movement: National Board Certification of Teachers (National Board of Professional Teaching Standards [NBPTS], 1994) and the Advanced Masterís Degree (National Council for the Accreditation of Teacher Education [NCATE], 1998).

NBPTS and NCATE have formed a partnership that reflects the National Board Teaching Standards in the Advanced Masters degree proposed by NCATE (1998). Under the 1997 Excellent Schools Act, North Carolina is requiring universities in the state to restructure their Master Degree programs for teachers by December, 1999. This restructuring effort shifts the objectives of graduate education from scholarly preparation to professional development. The NCATE goals are aimed at increasing teachersí understanding of content and pedagogy so that teachers can act as agents of change in an increasingly complex world. While university teacher educators are moving forward with new or revised graduate education programs, it is important that teachers have an opportunity to give their opinions as to what will be most valuable to their professional development. Specifically we questioned what content and methods teachers valued among the proposed curriculum areas for the Advanced Masters degree.

Framework

This two-part study was framed in the context of three current influences: (a) the core propositions of the National Board for Professional Teaching Standards, (b) the core competencies proposed for inclusion in the Advanced Masterís Degree programs required in North Carolinaís universities, and (c) the sociocultural frameworks of learning.

The NBPTS core propositions include the following: (a) commitment to students and their learning, (b) knowledge of subjects and subject-specific pedagogy, (c) responsibility for managing and monitoring student learning, (d) systematic reflection about practice, and (e) participation in learning communities (NBPTS, 1994). Reflecting the direction of the NBPTS, the North Carolina Advanced Masters core competencies address five areas: a) instructional expertise including theory, philosophy, and research, b) knowledge of learners, c) research expertise to examine and improve instruction, d) ability to connect subject matter and learners, and e) professional development and leadership.

A theoretical framework, implicit in the priorities of both the NBPTS, NCATE, and the North

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Carolina Advanced Masters competencies, is that suggested by sociocultural analysis. Traditional learning theories have emphasized the transmission of existing knowledge without recognizing the invention of new knowledge in the context of practice (Chaiklin & Lave, 1993). The work of sociocultural analysis has provided a means to relate mental functioning to a cultural, institutional, and historical context (Wertsch, 1998). The proposed graduate programs incorporate the theoretical foundations of sociocultural analysis by combining the complex relations among person, activity, and situation into a single entity, encouraging the teacher to learn in the context of their practice and reflection on that practice.

This study consists of two parts. The first part examined 467 teachersí anonymous responses to a paper and pencil survey. The emphasis in Part One of the study was to gather information about the teachersí needs with respect to the curriculum aspects of graduate study. Researchers interviewed teachers individually in Part Two of the study to determine the pedagogical issues associated with university instruction.

Part One: Design and Procedure

A survey was designed to gather demographic information, beliefs, and attitudes anonymously from teachers about the proposed changes to the Advanced Masters degree. For this study, 300 science and mathematics teachers attending 1998 summer workshops at 10 Mathematics and Science Education Network [UNC-MSEN] centers across the state of North Carolina completed the survey. An additional 167 middle grades and high school mathematics and science teachers from a large rural county completed the survey. Frequency data are reported below that reflect trends in teachersí thinking. Then data were reexamined to investigate relationships among the survey data. The survey was developed with three sections: a) demographic teacher data; b) relative importance of graduate curriculum; and c) Likert statements defining the graduate curriculum. The demographic data collected in Section 1 included years of teaching, education degrees, National Board Certification, incentives and barriers for pursuing an advanced masters degree. In Section 2, teachers considered seven areas of professional development to determine which were of greater professional value by ranking them 1-7 and determining what percent of their degree programs should be devoted to these areas. The seven areas were knowledge of: a) instruction, b) learners, c) research, d) subject matter and learners, e) teaching practice, f) assessment, and g) professional development and leadership. These curriculum areas represent a synthesis of the NBPTS core propositions and the NC Core Competencies and together are shown in Table 1 in the column headed Survey Sections. The 30 items in Section 3 of the survey were drawn from these categories as well.

Table 1.

Relationships between the NBPTS Core Propositions, the N.C. Core Propositions and the Survey Sections

NBPTS Core Propositions	NC Core Competencies	Survey Sections
• Commitment to Students and Learning	Knowledge of Learners	Knowledge of Learners - Diversity, intellectual, physical, and emotional development

• Knowledge of Subject and Subject Pedagogy	Connect Subject Matter to Learners	Knowledge of Subject Matter and Learners - Content knowledge, best teaching practice for student learning in specific disciplines
	• Instructional Expertise - Theory, philosophy, and research	Knowledge of Instruction - Theories, philosophies, research, current practice
		• Teaching Practice - Applications of teaching strategies, management, pedagogy
• Manage and Monitor Student Learning	Research Expertise - Examine and improve instruction	Assessment - Assessing oneís own teaching practice, student learning, program effectiveness • Research - Data collection methods, interpretation of findings
• Reflection about Practice		
• Participation in Learning Communities	Professional Development and Leadership	Professional Development and Leadership - Professional inquiry, collaboration, mentoring

The instrument development occurred over several weeks beginning with a review by a panel of experts and concluding with trials and interviews with a dozen K-12 science and mathematics teachers. Surveys were mailed to UNC-MSEN center directors or principals who distributed them to teachers attending summer workshops or employed in their schools. While some sections were left blank, the response rate on most questions was over 83%.

Part One: Data Analysis and Findings

The data were entered into an Excel spread sheet and then tabulated to determine the frequency distribution of items in the three sections of the survey. Chi square tests compared teachers opinions on Likert items in Section 3 by graduate education level (Section 1).

Section 1. The majority of teachers in this sample had more than six years of teaching experience (69%), although 38% of the sample were seasoned educators with more than 15 years of experience. Thirty three teachers reported having National Board Certification (7%) and one-third of the teachers stated that they planned to pursue National Board Certification in the future. Approximately one-third of the teachers reported that they currently held a Masters degree. Twenty-one percent of the remaining 319 teachers, plan to obtain a masters in elementary education, 35% in middle grades mathematics and/or science, and 26% in high school mathematics or science. This information provides some evidence that many teachers in this survey plan to stay in their classrooms rather than to aim for administrative positions. Teachers reported that the most important incentives to pursue a graduate degree were: 1) to improve their teaching (58%), 2) to gain financial rewards (53%), and 3) to improve studentís learning (53%). Enumerating the barriers they faced to obtaining a masters degree, teachers listed time (65%), money (60%), and family (13%) as obstacles for future professional development.

Table 2.

Percent of Teachersí Rankings of Advanced Masters Curriculum Areas

Rankings	Instruction	Learners	Research	Subject Matter	Teaching Practice	Assessmnt	Prof. Dev./ Leadershp
First	14	16	6	56	25	9	7
Second	13	15	8	18	29	14	9
Third	13	24	9	7	16	17	11
Fourth	12	19	10	8	12	16	14
Fifth	19	14	13	4	8	19	15
Sixth	18	8	21	2	7	14	16
Seventh	10	5	32	4	4	9	26
First - Third	40	55	23	81	70	40	27

These rankings are based on responses from 379 teachers. Fifteen percent of the total teachers surveyed did not respond to the questions in Section 2.

Section 2. Table 2 presents the percent of teachersí priority rankings of the seven curriculum areas. Knowledge of subject matter and learners (56%) and teaching practice (25%) received the highest teacher rankings while research (6%) and professional development and leadership (7%) ranked

lowest. The remaining three curriculum areas; instruction, learners, and assessment, were ranked more evenly, indicating that teachers thought these areas were necessary, but not essential, for them to study.

Consistent with the curriculum rankings were the results of instructional time teachers recommended spending on each of the seven curriculum areas. More program time was recommended for subject matter knowledge, teaching practice, and knowledge of learners, while less time was recommended for professional development, assessment, and research.

Section 3. Twenty-nine of the 30 Likert items were clustered into six groups: instruction, learners, research, subject matter/teaching practice, assessment, and professional development/leadership. For this analysis, the previously used categories of knowledge of instruction and Teaching Practice were combined into one category. Teachersí opinions, shown in Table 3, were positive about all six curriculum areas and teachers were in more agreement on the assessment items than any of the other areas.

Table 3.

Percent of Teachersí Opinions Concerning Specific Instances of the Advanced Masters Curriculum Areas in Section 3

Opinions	Instruction	Learners	Research	Subject/ Tchg. Practice	Assessment	Prof. Development/ Ldrship
Agree	50	74	57	69	74	63
No Opinion	19	5	17	8	7	16
Disagree	14	5	9	6	3	5
No Response	17	16	17	17	16	16

With the exception of knowledge of instruction, teachers were similar in their views regardless of their educational levels. Items in this Instructional category Included the following items:

1. *It is important for my professional development to read journals and books in my field.*
2. *I am very interested in theories of learning.*
3. *I expect a Masters Degree will change my philosophy of education.*
4. *It will be beneficial for me to make connections between theory and practice.*
5. *It is essential for me to learn theory, philosophy, and research to improve my studentsí achievement.*

Item three received more variable opinions than any other item in the survey with 34% agreeing with the statement, and 37% disagreeing with the statement. Further analysis compared teachersí opinions in this instructional category according to their educational levels, those with Masters degree and those with Bachelors degrees. As shown in Table 4, teachers who had obtained a Masters degree seemed to value the connections between theory, research, and practice more than those with only an undergraduate degree

Table 4.

Chi Square Comparison of Knowledge of Instruction of Teachers with and without Masters Degrees on Items 1-5.

Level of Education	Agree	No Opinion	Disagree
Masters Degree	67.3%	19.4%	13.4
Bachelors Degree	59.3%	23.8%	16.8

chi-square = 13.335, 2 d.f., Significance Level = .001

Part Two: Design and Procedure

An interview protocol was developed to gather information from four teachers concerning their pedagogical preferences for graduate courses. The teachers were asked to identify and give examples of class formats that they preferred as adult learners. Second, teachers were asked about the kinds of course assessments that were most beneficial to them. Finally teachers responded to a set of questions about incorporating their own studentsí work or video tapes of their teaching into Masters level courses. Three of the four teachers did not have a Masters degree, but were considering pursuing one. The protocol was slightly modified for the teacher who already had a masters degree. Two of the teachers taught science, one at the high school level and one at the middle grades level; and two teachers taught mathematics, one at the high school level and the other in middle grades.

Part Two: Data Analysis and Findings

Video tapes of these interviews were transcribed and categorical analysis was used to analyze the data (Stake, 1995). Categorical analysis requires that multiple instances of ideas be found among the data, thereby giving meaning to the relevant issues. Once the categories are established, a search for patterns among the categories is made to determine any relationships existing between two or more categories (Creswell, 1998).

Category 1: Professional Attributes

This category encompasses the attributes that each of these teachers value in their own teaching. Several themes emerged from the data when the teachers were asked to describe their teaching strengths. First, teachers perceived that they were creative, using a variety of techniques to engage their students in learning mathematics or science.

> Lois: *I do try to vary my lessons. ...we have labs, some lecture-talk instructions, weíll work in small groups, students teaching each other. ... I really go into multiple intelligence type things. If I donít know all the different areas I need to cover then I canít help all the different learners I have in my room. So I do try to vary instruction in that way... I donít think you should stay in a lecture method, or you should do labs all the*

time.

Mona: *I love being creative and inventing. Now Iím working with a colleague and she incorporates a lot of the math ... and with my science weíre all the time integrating.*

Nancy: *I kind of have a knack for questioning ... trying to get the students to come up with things ... develop their own ideas, instead of - "Here it is and you all do it."*

Opal: *I try to expose my students to lots of things. Many of them come from deprived backgrounds and I try to bring in people from various science-related careers to let them know about possibilities for the future.*

A second theme in the professional attributes category that was universally represented among these teachersí professional values was their concern for their students.

Lois: *I feel that I am very approachable to the students as far as asking questions or coming for extra help. I allow my student to know that Iím human and I make mistakes too and I encourage them to question me ...*

Mona: *I donít give up on the kids. I love all of them, even though some can aggravate the mess out of you. But, in the long run you always look for the good in there, because you never know* [how] *they are going to turn out.*

Nancy: *[I] just try to really never emphasize ëthatís rightí or ëthatís wrong.í Instead letís look at what is right about it as well as what we can maybe improve on. And just try to have a non-threatening atmosphere.*

Opal: *Well I try to relate to my students outside of class ... things theyíre involved in. I try to attend those things and make sure they see me there. They know I care about them as people and not just as students.*

The professional attributes that teachers value in their own teaching may also be factors that they may value in their future university professors. To test this assertion we turn to data represented in the second category, Professional Studies Pedagogy. This category contains the information concerning teachersí choice of instructional environments.

Category 2: Professional Studies Pedagogy

The teachers expressed definite ideas about the kinds of classroom formats and teaching strategies they expected in an ideal graduate class.

Lois: [I want to see] *more interaction and discussion because I think as an experienced educator, now I have things I can offer.*

Mona: *Iím a hands-on person. I mean you can lecture me until youíre blue in the face and Iím like ëyeah, uh-huh,í but if I donít see it, I donít understand it. Iím a visual learner.*

Nancy: *I like a variety of formats, donít prefer one way all the time, including the instructorís presentation of ideas, Especially when* [the instructor] *is guiding us through different philosophies of education and different theories* [of learning]. *Then*

student interaction [is important] *as far as different ideas.*

Opal: *It is better to have a group of topics to pick from than just one age-appropriate or course-appropriate one.*

The intersection between what these teachers value in their own teaching and what they value about their own learning formats in graduate school is apparent. They value a variety of formats, with opportunities to discuss their own teaching. They are not strong advocates for graduate courses with lecture formats. We may make the inference that these teachers want to be treated respectfully and as professionals by the university faculty. They expect that their extensive and rich professional insights will be valued in Masters level courses.

Category 3: Collegiality

The collegiality category emerged from the data as teachers described themselves and their colleagues as professional with a variety of experiences and a store of knowledge to be valued. They held the collective opinion that opportunities should be provided in graduate classes for them to use this professional knowledge.

Lois: *I donít believe in reinventing the wheel. I think everybody has something to offer and that I should hope that this would be brought out in class instead of more lecture, sit down, take notes, and listen.*

Mona: *Now Iím working with a colleague; before Iíve always had to do it on my own. I think she and I are on the cutting edge ... I really think there is a time when teachers can say, "Hey, Iíve got this great idea. Look at this."*

Nancy: *People are doing different things at different schools ñ some more technologically oriented; others might have other projects. A lot of that can come out through graduate student interaction ...*

Opal: [It would be good to] *develop instructional materials cooperatively. Give us time to work together to do that* [in graduate school].

When we examine the data in this Collegiality category, it is apparent that these teachers view their role in graduate education more participatory than in traditional graduate education courses. Therefore, we examined how these teachersí viewed the role of the university professor.

Category 4: University Mentors

The fourth category contains teachersí ideas about the role of the university faculty. The teachers indicated that they welcomed the professor into their classrooms as mentors. They viewed these mentors as partners who would work collaboratively with the teacher to improve instruction.

Lois: *I think it would be nice to have, I donít know if this is the word for it, a lab type situation. Maybe even where the professor would come into the classroom and observe your implementing the ideas and strategies talked about in class. I appreciate people who can come in and give* [advice] *constructively.* [He/she could] *say, ëThis wasnít clear,í or ëThis was shaky,í or ëYou might improve here,í because the point is that the student learn. Itís not about* [me] *being a great teacher. Itís rather about the students having a handle on what youíre talking about or not.*

Mona: *I think it* [university mentors in the classroom] *would be beneficial because then it could help you see where you need to grow, where you need to improve.*

Nancy: *I would like even having a partner, a fellow student, if time constraints would not allow the instructor* [to visit] *...kind of like a peer coaching situation.*

Opal: *They would be viewing that from a different perspective than your supervisor. It would be a ëIím here to help ... letís see what youíre doing. What can I give you some pointers on?í Itís not ëOh my gosh, my supervisorís coming.í Somebody else is coming whoís going to help me find a way to do something Iím doing better.*

We conjecture that teachers have a new vision for graduate education. This vision includes new roles for themselves as graduate students and new roles for university faculty. These teachers envision that they will bring their professional knowledge and experience to a university classroom that will value what they know about teaching and learning. Additionally, these teachers hold the expectation that their professors will be able to mentor them in a collegial relationship within the real experiences of classroom teaching.

Summary

A number of scholars have noted that a paradigm shift is needed in graduate education. The past preoccupation of universities with academic work will be transformed to incorporate a scholarship of application. Considering that learning is a process of making meaning, teachers recognize the importance of understanding how students learn. It is from these and other contemporary perspectives that the study of teaching and learning emerges as a key element of graduate education for science and mathematics teachers.

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